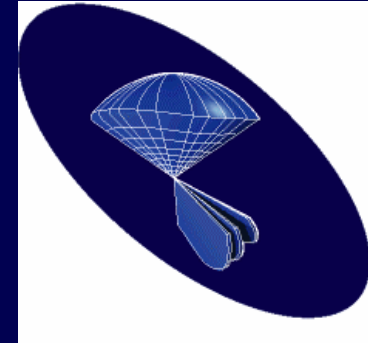


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*SDSS-II*  
*Cost, Schedule, Contingency, Risk*

---



Bill Boroski

NSF Reverse Site Visit / Panel Review  
February 17, 2005

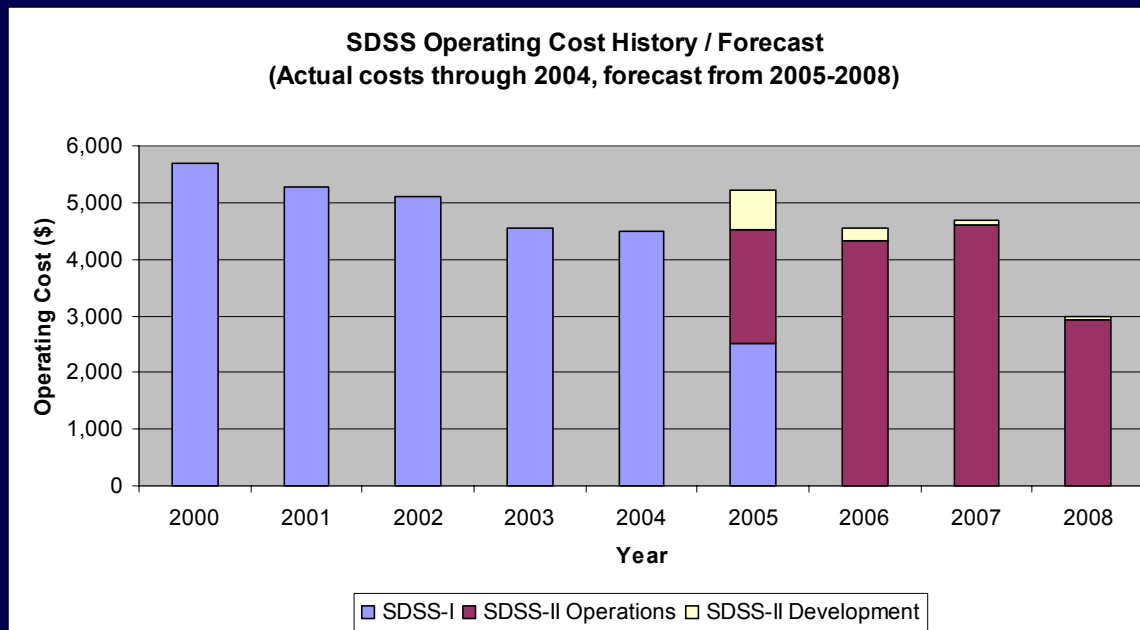
# *SDSS-II Budget Overview*

---

- Total estimated cost for SDSS-II = \$14.9 million
  - Operations = \$13.9 million
  - New development = \$1.0 million
- Budget anticipates in-kind contributions and provides for cash expenses
  - Estimated value of anticipated in-kind contributions = \$1.95 million
  - Estimated cash expenses = \$12.96 million
    - Includes \$305K in management reserve (~2% of total budget)
- Budget is organized by WBS
  - Costs are tracked to level 3 in the WBS
- Distribution of project costs
  - Total project cost is the same as that contained in our NSF proposal (\$14.9 MM)
  - Distribution of costs has changed to match re-organized WBS

# SDSS-II Operations Budget

- Estimated cost for operations = \$13.9 million
  - 93% of total SDSS-II budget
- Basis
  - All of the hardware and software developed for and used in SDSS-I will be used for SDSS-II; Legacy Survey is a continuation of SDSS-I operations.
  - Four years of SDSS-I operating experience



*Operations in Year 2000 covered the period Apr-Dec (9 months); actual expenses have been annualized for this comparison.*

## *Operations Budget, organized by WBS (in \$000s)*

---

<u>1.0 Survey Management</u>	1,629
<u>2.0 Survey Operations</u>	
2.1. Observing Systems	2,552
2.2. Observatory Operations	5,174
2.3. Data Processing	2,390
2.4. Data Distribution	1,451
2.5. ARC Support for Survey Ops	<u>207</u>
Survey Operations Sub-total	11,774
 <u>4.0 ARC Corporate Support</u>	 179
<u>5.0 Public Outreach</u>	0
<u>6.0 Management Reserve</u>	305
Total	<u>13,887</u>

# Observing Systems

---

- Comprises all of the hardware and software used at Apache Point Observatory (APO) to conduct SDSS operations.
- All of the hardware and software developed for SDSS-I will be used for SDSS-II
  - 2.5m Telescope, Photometric Telescope, imaging camera, (2) spectrographs, (9) fiber cartridge assemblies, ancillary support systems;
  - Software used by the observers to control the telescopes and instruments; and the data acquisition system used to collect data.
- All of the hardware and software used at the University of Washington to fabricate SDSS-I plug plates will be used for SDSS-II.
  - Custom drilling fixture, thermally-controlled drilling machine, code to run the drilling machine, fixturing and software for the Coordinate Measuring Machine used in the plug plate QA process, database used to record QA results.

## Observing Systems (2)

---

- No major development work planned beyond the DA upgrade.
- Risks and uncertainties
  - Catastrophic failure of a telescope system or instrument
    - *Preventive maintenance program and active monitoring of system performance*
  - Component obsolescence
    - *Addressing through an improved sparing program*
  - Obsolete and problematic data acquisition system
    - *Addressing through planned DA upgrade*
  - Loss of institutional knowledge
    - *Staff turnover may cause a loss of institutional knowledge*
    - *Attempting to address this through improved operating procedures and documentation, cross-training, etc.*

# *Budget for Observing Systems*

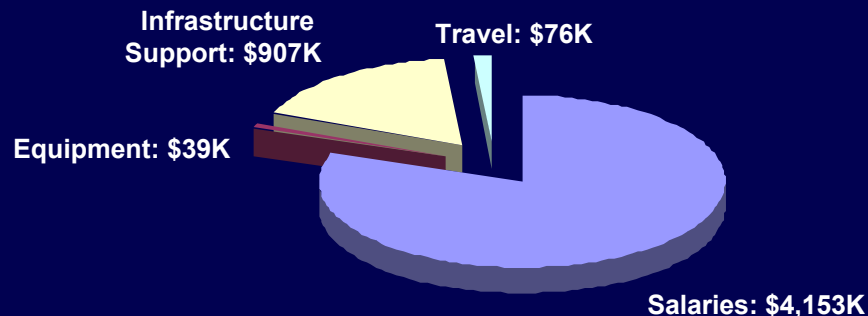
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- Observing Systems budget = \$2.55 million
  - 17% of total operating budget
  - Annual operating cost: ~\$860K
  - Budget provides support for the following:
    - Salary support for on-mountain technical staff to support and maintain the SDSS telescopes, instruments and support systems at APO. These individuals reside near the observatory. (3.5 FTEs/year)
    - Salary support for off-mountain personnel who assist the on-mountain staff with technical issues and oversee plug plate production. (1.8 FTEs/year)
    - Funds for replacement parts, mirror aluminizing, minor improvements, etc.
    - Plug plate production costs (~\$237/plate).
    - Modest travel expenses for technical staff
  - Basis: SDSS-I operations experience

# Observatory Operations Budget

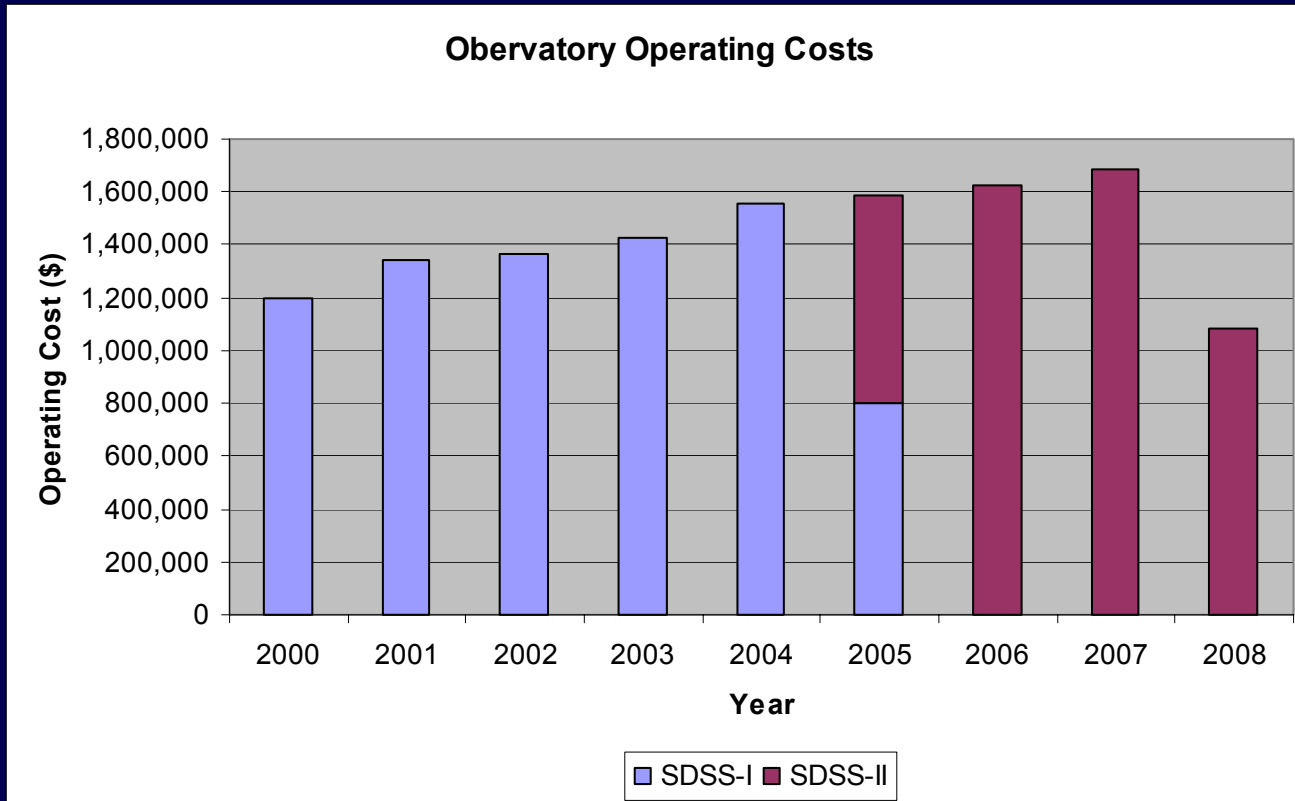
---

- Forecast of observatory operating costs = \$5.174 million
  - 37% of total operating budget
  - Annual operating cost of ~\$1.7 million
- Provides for the following:
  - Salary support for 8 observers to operate the telescopes and instruments and collect data
  - Salary support for 6.4 FTEs of site support staff (technical and admin)
  - Observatory infrastructure expenses (utilities, expendables, site maintenance and repair, etc.)
  - Modest travel expenses for observers and site staff to attend project meetings
- Observatory operations budget by category:



# Basis for Observatory Operations Budget

- Basis for SDSS-II observatory operations budget = past operating experience, scaled for inflation



- Years 2000-2004 set to actual expenses
- Year 2008 covers operations through June 2008 and closeout activities through Sep 2008.

# *Data Processing Operations*

---

- Core data processing operations occur at Fermilab
  - Data is transferred from APO to Fermilab and processed in a production manner in the “DP Factory”
  - All of the existing infrastructure from SDSS-I will be used for SDSS-II.
    - Large array of computer systems
    - Imaging data reduction software (PHOTO)
    - Spectroscopic data reduction software (idlSpec2D and Spectro-1D)
    - Photometric Telescope data reduction pipeline (MTPipe)
    - Quality assurance tools used to assess and verify data quality
    - Target selection software used to select objects and design plates (Target)
    - Web pages that track and document data processing status
    - Numerous scripts, backup mechanisms and other infrastructure tools that make data processing run efficiently and effectively.
- SEGUE spectroscopic data processing operations will occur at Princeton
  - Computer systems are currently in place and used to process and calibrate SDSS-I data independently from the DP Factory;
  - This infrastructure will be used for SDSS-II SEGUE data processing; only minor revisions to the system are required.

# *Budget for Data Processing Operations*

---

- Budget for data processing operations = \$2.39 million
  - 17% of total operating budget
  - Annual operating cost: ~\$800K
  - Provides for the following:
    - Salary support for scientists and computer professionals who oversee and perform core data processing operations (5.25 FTEs/year);
    - Salary support scientists and computer professionals who developed and now maintain the data reduction software, and assist in data testing and analysis in preparation for data releases (2.5 FTEs/year);
    - Replacement computer hardware, DLT tapes, software licenses, misc. supplies;
    - Modest travel expenses
  - Basis: SDSS-I operations experience

# *Data Distribution Operations*

---

- Core data distribution operations occur at Fermilab
  - For each data release, data is loaded onto servers (Data Archive Server) and into databases (Catalog Archive Server), web interfaces are updated, documentation is updated, and the new data analyzed.
  - Support activities include running a helpdesk, maintaining and upgrading hardware as required, procuring new hardware to meet growing data volume needs, and improving database software as required.
  - All of the existing software and hardware in place for SDSS-I will be used for SDSS-II.
    - Software associated with the DAS, CAS, SkyServer, and CasJobs;
    - Computer hardware clusters associated with the DAS and CAS;
    - Infrastructure systems;

# *Budget for Data Distribution Operations*

---

- Budget for data distribution operations = \$1.45 million
  - ~10% of total operating budget
  - Annual operating cost: ~\$480K
  - Provides for the following:
    - Salary support for scientists and computer professionals who oversee and perform core data distribution operations (2.5 FTEs/year);
    - Salary support for scientists and computer professionals who developed and now maintain the software associated with the SkyServer / Catalog Archive Server, and who host a duplicate copy of publicly released data (1.3 FTEs/year);
    - Replacement computer hardware, DLT tapes, software licenses, misc. supplies;
    - Modest travel expenses
  - Basis: SDSS-I operations experience

# ARC Corporate Support Budget

---

- Budget for ARC Corporate Support = \$179K
  - ~1% of total operating budget
  - Annual operating cost: ~\$60K
- Provides support for “corporate” functions and activities
  - Public affairs:
    - *AAS meeting expenses*
  - Collaboration affairs:
    - *Travel support for Working Group Chairs*
  - Support for Observing Systems:
    - *Funds held for miscellaneous needs and additional engineering staff*
  - Corporate support:
    - *Insurance, audit fees, bank fees etc*
  - Additional scientific support:
    - *Travel costs for Project Team Leaders, personnel replacement costs.*
  - Observers’ fund:
    - *Support for professional development*
- Basis: SDSS-I operating experience

# *Operations Budget Summary*

---

- Total operations budget: \$13.9 million
  - Includes salary support for ~33 FTEs/year
- Cost basis:
  - Four years of SDSS-I operating experience
- All of the existing infrastructure for SDSS-I will be used for SDSS-II.
- The only major upgrade planned to support on-going operations (i.e., the Legacy Survey) is to the data acquisition system.
- Concerns
  - Management reserve of \$305K is only 2% of budget. We regard this as low, despite the fact that we have never had to use funds the management reserve in SDSS-I.

## *Q&A on the Operations Budget*

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## *Development Budget, organized by WBS* (in \$000s)

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### 3.0 New Development

3.1	SEGUE Project Development	\$ 369K
3.2	Supernova Project Development	\$ 258K
3.3	Photometric Calibration	\$ 146K
3.4	DA Upgrade	<u>\$ 241K</u>
	New Development Sub-total	\$1,013K

# *SEGUE Development Work*

---

- SEGUE development work is captured under WBS # 3.1
- Software development tasks were discussed in detail in the SEGUE talk. Partial list includes:
  - Refining existing target selection and data reduction code;
  - Refining existing data quality assessment tools to monitor and verify SEGUE data quality;
  - Modifying existing data distribution code and systems (Data Archive Server and Catalog Archive Server) to accommodate SEGUE data.
- New hardware requirements:
  - New computing hardware is required to augment the existing DP system at Princeton. A high-end dual-processor PC with sufficient disk will support the addition of SEGUE spectroscopic data processing. Est. cost = \$30K.
  - Three new database servers will be required to load and serve processed SEGUE data to the collaboration and general public. Est. cost = \$40K.

## *SEGUE Development Timeline*

---

- Work is underway on many aspects of the SEGUE work list.
- Goal is to have target selection code completed by July 1, 2005, in time to select spectroscopic objects, and design and fabricate plug plates, in time for the fall 2005 observing season.
- Work in other areas will continue into the fall observing season.
- We need to hire additional staff to perform some of the development work and to run the SEGUE spectroscopic data reduction system.
- We have captured the work to be done in the project WBS. We need to convert the task list into a schedule with milestones.

# SEGUE Development Budget

---

Salaries		\$ 282K
Travel		11K
Materials & Supplies		
Spectro DP hardware	30K	
Database servers	40K	
Miscellaneous	6K	
M&S sub-total		76K
TOTAL		\$ 369K

*The salary budget supports the following effort profile:*

	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Level of effort (FTEs)	2.35	1.60	0.30	0.30

# *Supernova Development Work*

---

- SN development work is captured under WBS #3.2
- Software development tasks were discussed in detail in the Supernova talk. Partial list includes:
  - Modifying the Frames subtraction pipeline;
  - Refine spectroscopic target selection code;
  - Further script development to automate data processing;
  - Further development of the Supernova Candidates Database and associated web interface;
  - Further development of off-mountain data analysis code;
  - Develop databases to serve SN data to collaboration and public.
- New hardware requirements:
  - A new compute cluster, comprising 8 to 10 high-end dual-processor PCs, with adequate disk, will be installed at APO to process SN data. Benchmark tests are underway to determine the precise type and quantity of hardware. Est. cost = \$40K.
  - New database servers will be required to serve SN data, and repeat imaging and/or catalogs, to the collaboration and general public. Est. cost = \$30K.

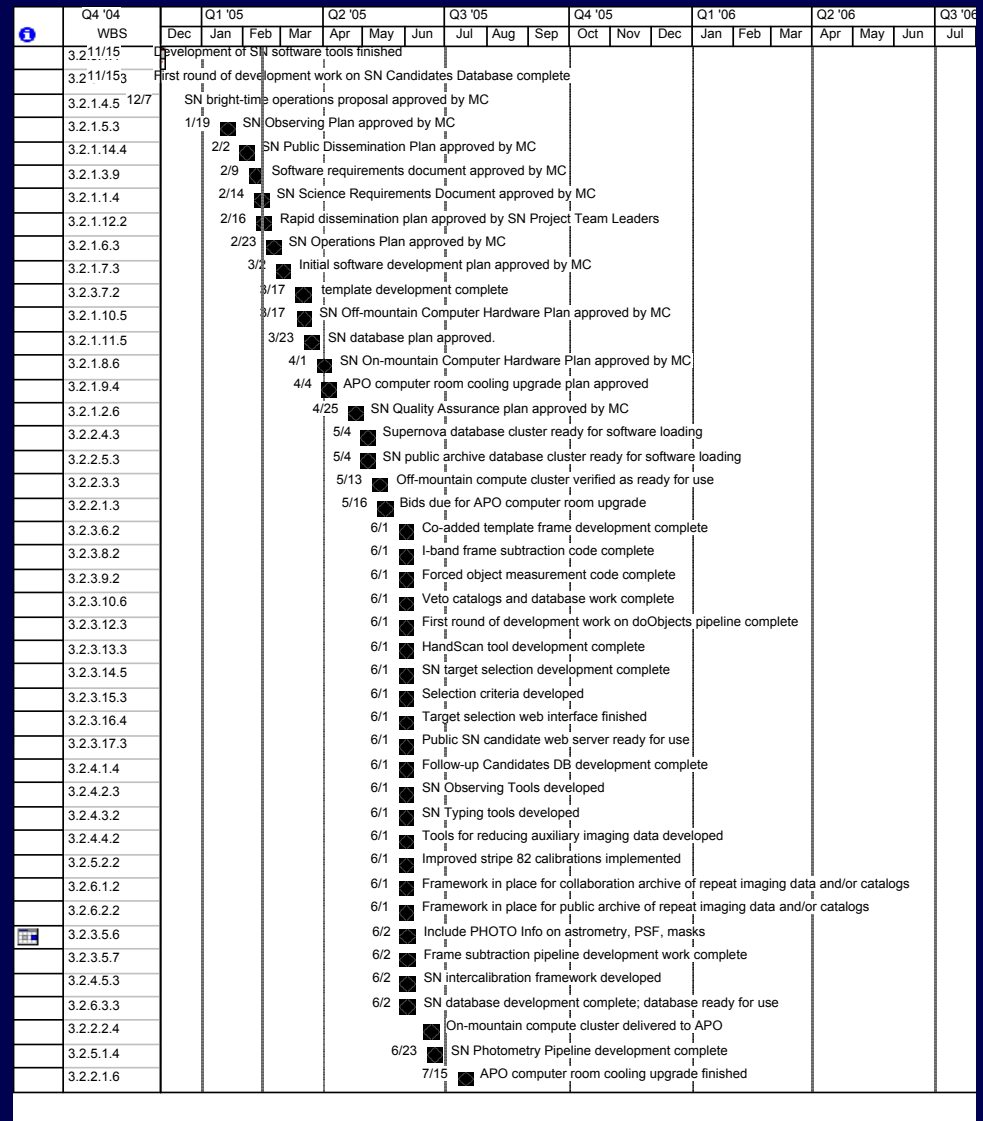
## *Supernova Development Work (2)*

---

- Potential APO infrastructure upgrade
  - Installing new computers in the computer room at APO will increase the heat load on the existing cooling system.
  - The additional heat load incurred by the SN computer cluster will be partially offset by a reduction in heat load realized through the DA upgrade.
  - Once the machines for the SN compute cluster are spec'd, we will perform a careful analysis of the revised heat load in the computer room and upgrade cooling capacity only if absolutely necessary.
  - Preliminary rough-order-of-magnitude estimates for a cooling capacity upgrade range from \$30-50K.
  - Funds are held in the ARC budget for Observing Systems Support for miscellaneous observing system needs. Funds from this account would be allocated as necessary to support the cooling room upgrade.

# Supernova Development Timeline

- Supernova tasks have been captured in the SDSS-II WBS and a preliminary schedule, with milestones, has been developed.
- We are in the process of refining the schedule with the appropriate level of detail to allow us to effectively monitor and track progress.
- The current milestone timeline, shown to the right, indicates that all Supernova development work should be complete, and the compute cluster in place at APO and ready for operation, by mid-August 2005.



# Supernova Development Budget

---

Salaries		\$ 172K
Travel		10K
Materials & Supplies		
APO compute cluster	40K	
Database servers	30K	
Miscellaneous	6K	
M&S sub-total		76K
TOTAL		\$ 258K

*The salary budget supports the following effort profile:*

	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Level of effort (FTEs)	2.50	0.0	0.0	0.0

# *Photometric Calibration Work*

---

- SDSS photometric calibration is now good to order 2% rms; using scan overlaps and a series of perpendicular “Apache Wheel” scans to tie the photometry together promises to improve this to of order 1%.
- Work on the photometric calibration effort is purely analysis and software-related.
- Development of the code to reduce Apache Wheel data is well along and AW data collected during SDSS-I is now being reduced.
- Remaining tasks include:
  - Integrating ubercalibration code into photo-op and providing testing outputs;
  - Testing output calibrations for systematic effects and statistically significant spatial structure;
  - Developing code to make FITS binary tables to use for post-calibration of DP factory outputs;
  - Analyzing white dwarf spectra and other spectrophotometric data to provide the best possible calibration of SDSS photometry onto an AB system;
  - Running the photo-op and spectro robots at Princeton.
- This work has been captured in the WBS; we need to convert the task list into a realistic schedule with milestones.

# *Photometric Calibration Development Budget*

---

Salaries	\$ 142K
Travel	2K
Miscellaneous supplies	2K
TOTAL	\$ 146K

*The salary budget supports the following effort profile:*

	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Level of effort (FTEs)	0.25	0.50	0.75	0.75

# *DA Upgrade Work and Schedule*

---

- The problems:
  - DA system was delivered in 1995;
  - Component obsolescence and maintainability are real concerns; the MVME167 processor boards that provide the primary interface between the instruments and the DA, are obsolete and no longer available.
  - The PTVME link, through which all data transfers occur, is unstable; causes problems during high-speed scans;
  - The existing “host” computers are old and slow; licensing and maintenance contracts are expensive;
  - Writing to DLT tapes is expensive;
  - Current DA design prohibits rapid access to imaging data.
- The planned solution:
  - Replace the MVME167 boards with Motorola MVE5500 PowerPC boards;
  - Port existing software onto the new platform;
  - Replace old “host” computers with new dual-processor PCs;
  - Emulate the functionality of the PTVME link in software;
  - Incorporate the ability to write data to hot-swappable disk drives;
  - When finished, we will have a more robust, more maintainable system that will also provide faster access to the data, which will benefit QA procedures and Supernova data processing turn-around times.

# DA Upgrade Schedule

[illegible]

# DA Upgrade Budget

---

Salaries		\$ 126K
Travel		10K
Materials & Supplies		
(18) DLT tape drives	7K	
(19) PowerPC boards	61K	
(2) dual-processor PCs (primary & spare)	9K	
(1) dual-processor PC (test stand)	5K	
VX Works software license	8K	
Other miscellaneous	15K	
M&S sub-total		105K
TOTAL		\$ 241K

*The development salary budget supports the following effort profile:*

	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>
Level of effort (FTEs)	1.15	0.0	0.0	0.0

*The SDSS-II budget holds another \$50K for the DA upgrade in the ARC observing systems account.*

# Development Budget Summary

---

## Budgeted level of effort:

					Total
<u>Level of effort (FTE-yrs)</u>	<u>2005</u>	<u>2006</u>	<u>2007</u>	<u>2008</u>	<u>(FTE-yrs)</u>
SEGUE development	2.35	1.60	0.30	0.30	4.55
Supernova development	2.50	0	0	0	2.50
Photometric calibration	0.25	0.50	0.75	0.75	2.25
DA upgrade	<u>1.15</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1.15</u>
Total	6.25	2.10	1.05	1.05	10.45

Total estimated development cost = \$1.013 million

No contingency is set aside specifically for development work. Contingency is held with the management reserve for the rest of the project.

# Project Cost Summary

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- Total project cost = \$14.9 million
  - \$13.9 million for operations
  - \$1.0 million for new development
- Basis:
  - 4.5 years of operating experience with SDSS-I;
  - Budgets for new development based on the scope of work captured in the WBS, input from the Project Team leaders and technical staff, and experience gained during SDSS-I development.
- Cost risk:
  - The operations budget is mostly salaries that are already in place and predictable;
  - Development costs are ~7% of the total project cost; detailed work plans provide solid basis for estimation.
- Cost Control Mechanisms
  - Cost control systems, effective in SDSS-I, will continue to be used for SDSS-II
    - Annual operating budgets approved each year by the ARC board
    - Actual cost performance is compared to plan and documented in the quarterly progress reports
    - All personnel changes, and procurements >\$3K, require approval of the SDSS Director.
    - All computer purchases require approval of the Director and ARC Business Manager.
    - We have not exceeded an approved budget since we started operations in April 2000.
- Contingency
  - At ~2%, management reserve is low for a project of this scope.
  - We have never had cause to use funds from the SDSS-I

# *Project Schedule Summary*

---

- Progress with respect to the Baseline Plan will be reported in the quarterly progress reports and posted on [sdss.org](http://sdss.org), as it is now.
- Data Release 3 was made available to the public according to the approved schedule and we are on track to release Data Release 4 in July, also on schedule. We do not anticipate problems meeting SDSS-II data release commitments.
- The scope of work for new development has been captured in the project WBS.
  - Formal schedules for completing new development work are under development.
  - Critical path and milestones will be used to monitor and track progress.
- Ideally, the DA upgrade will be completed before the start of the fall 2005 observing season. However, the existing system will not be taken off-line until the new system has successfully been tested and verified on a test bench.
- The software for the Supernova Survey needs to be in place in September, but an early version already worked last fall.
- Target selection code for the SEGUE project needs to be ready by July, in order for plates to be designed and drilled for the fall 2005 observing season; a preliminary version of the code exists and was used to successfully design plates that were observed in the fall of 2004.

# Technical Risks

---

- There are no new technical risks that we know of; data collection is essentially the same as for SDSS-I.
  - We demonstrated that we can successfully acquire and process data for the SEGUE and Supernova Surveys during the fall 2004 observing season
  - There are inherent risks in aging equipment; PM programs and sparing will remain important.
  - We continue to monitor all systems routinely, making changes conservatively.
- Hardware development is limited to the DA upgrade and the installation of new computer systems. Experience gained during SDSS-I operations will help minimize technical risks going forward.
  - Personnel who developed the original DA are working on the upgrade; they have a deep understanding of the system, which minimizes technical risks associated with the upgrade.
  - Implementation of a prototype Supernova compute cluster at APO in the fall of 2004 was used in the fall of 2004 to process SN data; the system provided insight into specifications and requirements for the final production system. Benchmarking is currently underway to determine the type and quantity of machines required for the production system.
  - Computing hardware currently exists at Princeton as part of the photo-op and spectro data processing systems and has been successfully used to process SDSS-I data. Installation of new hardware to process SEGUE spectroscopic data will leverage the experience gained during the installation and operation of the existing system.
  - Implementation of new database servers to serve SEGUE data will leverage experience gained during the installation of similar servers recently installed to host Data Release 3 and to load Data Release 4.



# SDSS-II Budget Forecast (in \$000s)

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## ***Budget as shown in the NSF Proposal, Exhibit 1***

<u>1.0 Survey Management</u>	1,684
<u>2.0 Survey Operations</u>	
2.1 Observing Systems	2,931
2.2 Observatory Operations	5,000
2.3 Data Processing	2,952
2.4 Data Distribution	1,121
2.5 ARC Support for Survey Ops	<u>195</u>
Survey Ops Sub-total	12,200
<u>3.0 New Development</u>	
3.1 SEGUE Pipeline Development	101
3.2 SEGUE Database Development	242
3.3 Supernova Software Development	40
3.4 Photometric Calibration	<u>146</u>
New Development Sub-total	529
<u>4.0 ARC Corporate Support</u>	182
<u>5.0 Management Reserve</u>	305
Total	<u>14,900</u>

## ***Current Forecast***

<u>1.0 Survey Management</u>	1,629
<u>2.0 Survey Operations</u>	
2.1 Observing Systems	2,552
2.2 Observatory Operations	5,174
2.3 Data Processing	2,390
2.4 Data Distribution	1,451
2.5 ARC Support for Survey Ops	<u>207</u>
Survey Ops Sub-total	11,774
<u>3.0 New Development</u>	
3.1 SEGUE Project Development	369
3.2 Supernova Project Development	258
3.3 Photometric Calibration	146
3.4 DA Upgrade	<u>241</u>
New Development Sub-total	1,013
<u>4.0 ARC Corporate Support</u>	179
<u>5.0 Public Outreach</u>	0
<u>6.0 Management Reserve</u>	305
Total	<u>14,900</u>

# *NSF-Funded Activities (in \$000s)*

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## 2.0 Survey Operations

### 2.1 Observing Systems

Salaries	657
Travel	20
Materials and supplies	500

### 2.2 Observatory Operations

Salaries	2,048
Travel	30
Materials and supplies	117

### 2.3 Data Processing

Pipeline support and maintenance	513
SEGUE spectroscopic data processing	97

### 2.4 Data Distribution

Salaries	756
Travel	27
Hardware and supplies	<u>146</u>

Survey Operations Sub-total 4,911

## 3.0 New Development

SEGUE Pipeline Development	101
SEGUE Database Development	242
Photometric Calibration	<u>146</u>

New Development Sub-total 489

Total 5,400